The Effect of Off-Road Vehicles (ORVs) on beach invertebrates in the northeastern United States

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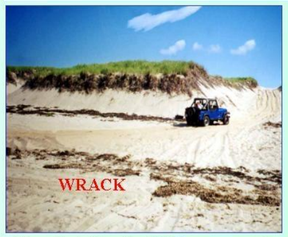
Abstract

We investigated the effects of off-road vehicles (ORVs) on macroinvertebrates inhabiting exposed sandy beaches in the northeastern United States. Abundances in pitfall traps set on beaches open to vehicles are consistently lower than on neighboring vehicle-free beaches, reflecting a decline in several species that burrow diurnally in the back-beach, where the vehicle corridors reside. Results from a direct impact study show that some species decline in numbers as the amount of traffic increases, while others may increase. Though wrack (seaweed debris) frequency and percent cover are lower on the beaches open to vehicles, this does not influence the overall abundance of detritivores on these beaches.

Introduction

A diverse assemblage of macroinvertebrates, including semi-terrestrial amphipods, insects, and spiders, use the marine detritus or wrack (macrophytes, grasses, and carrion) that washes up with storms and high tides on energetic ocean beaches for food, shelter, and breeding. These invertebrates are not only an important source of food for shorebirds (e.g., the threatened Piping Plover) and terrestrial predators, but they also help to break down the wrack and recycle nutrients to the ocean.



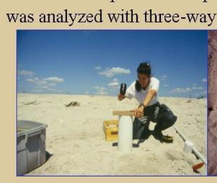
Race Point South: ORV access route

Samples taken at Fire Island and Cape Cod National Seashores

Approach

We used several observational and experimental techniques to determine whether off-road vehicle use can affect macroinvertebrate communities already adapted to harsh natural conditions.

1) Natural experiments: Wrack quadrats, cores (taken directly beneath wrack), and pitfall traps were used to sample four beaches, which all had vehicle-free sections in close proximity (25 m) to ORV corridors. Sailor's Haven on Fire Island was sampled for three periods in summer 1995, and two-way ANOVAs (traffic treatment ***x*** period) were used to analyze the data. Three sites on Cape Cod were sampled for two periods each for summers 2001 & 2002. Each year was analyzed with three-way ANOVAs (treatment ***x*** site ***x*** period).



Core samples

Wrack quadrats

Pitfall traps

2) Manipulative experiment: Mesh bags filled with sterilized *Zostera marina* debris (eelgrass) were placed on a remote beach, allowed to colonize, and were then subjected to treatments of high- , low-, and no-traffic. High-traffic bags were run over 10 times on each sampling day, low-traffic bags were run over 2 times, and controls were not run over. Sampling occurred over a 3-week period. Each sampling day, bags were retrieved and run through berlese extracting funnels. 2-way ANOVAs (treatment ***x*** period) were used.

Wrack treatment bags

Simulated traffic

Berlese funnels

Natural Experiments: replicate samples on four beaches

RESULT #1: Sampling methods preferentially capture different species.

Pitfall traps are dominated by talitrid beach hoppers (44%), adult diptera (22%), and adult coleoptera (10%).

Wrack/core samples are dominated by oligochaetes (52%), adult coleoptera (16%), and dipteran larvae (14%).

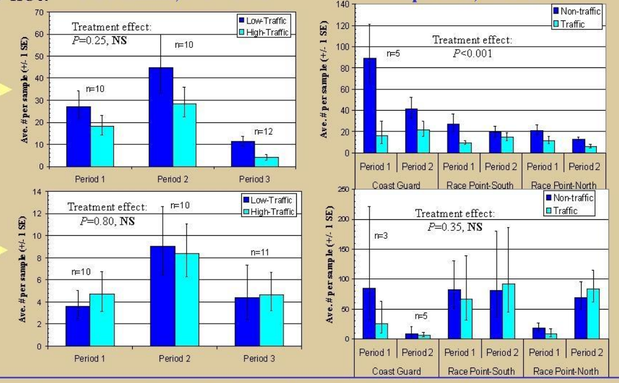
RELATIVE ABUNDANCES OF DOMINANT TAXA COMMON TO BOTH SAMPLING METHODS (based on Cape Cod, 2001 samples)

	Pitfall traps	Wrack/cores
Oligochaetes (undet. Enchytraeidae)	4.9	52.0
Amphipod: *Talorchestia longicornis*	35.5	1.8
Tethinid fly: *Tethina parvula*	11.6	11.4
Hydrophilid beetle: *Cercyon littoralis*	< 1	12.1
Amphipod: *Talorchestia megalopthalma*	8.1	< 1
Histerid beetle: *Hypocaccus fratermus*	7.4	< 1
Sphaerocerid fly: *Thoracochaeta brachystoma*	2.1	1.9
Lycosid spider: *Arctosa littoralis*	2.6	< 1
Other taxa	27.8	20.8
Totals:	1839	5476
Averages per sample +/- SE:	31 +/- 5	192 +/- 97

RESULT #2: Species captured by pitfall traps show a consistent response to traffic, but species caught in wrack/core samples do not.

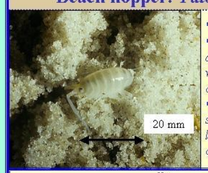
Pitfall trap results →

Localized wrack samples with underlying cores →



RESULT #3: Some species are consistently less abundant on beaches open to vehicles, while others are unaffected or respond positively to traffic effects.

Beach hopper: *Talorchestia longicornis*

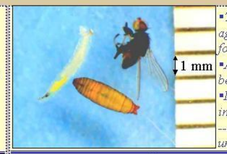


- *Lower abundances in traffic areas*
- *Adults burrow in back-beach by day, nocturnally feed on fresh wrack; desiccation-prone juveniles occur in wrack or near water's edge*
- *T. megalopthalma, a sympatric species occurring seaward of the last high-tide line, does not seem affected by ORVs*

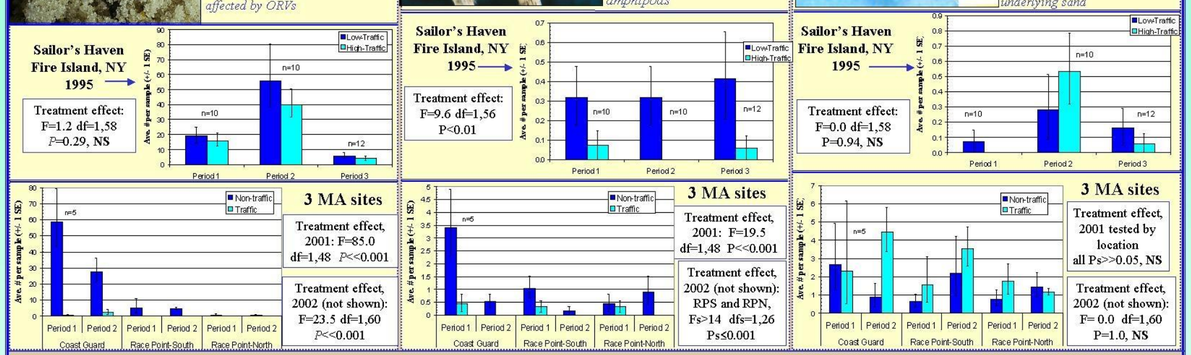
Wolf spider (Lycosidae): *Arctosa littoralis*

- *Abundances are consistently lower on beaches open to vehicle traffic*
- *Adults burrow in back-beach sands, immatures occur in wrack*
- *Known predators of talitrid amphipods*

Tethinid larvae/adults: *Tethina parvula*



- *This ubiquitous beach fly prefers aged wrack above the recent tides for mating/oviposition*
- *Abundances often greater on beaches open to traffic*
- *Microphagous adults--common in pitfall traps, detritivore larvae --common in wrack clumps and underlying sand*



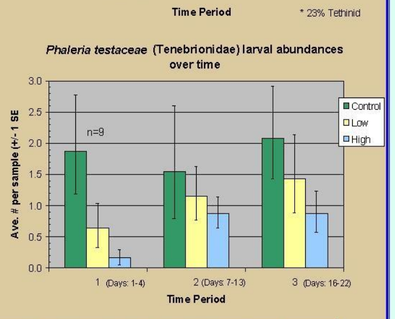
RESULT #4: Wrack debris occurs less frequently on beaches open to ORV traffic.

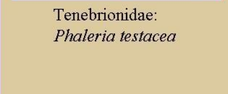
Average wrack cover per sample differed significantly with traffic effect, as did the overall frequency of wrack in vehicle corridors.

	Non-traffic	Traffic	Statistic	df	*P*-value
Average % cover in wrack quadrats	59 +/- 4	42 +/- 5	F=8.9	1, 44	0.005
Wrack volume (L) per sample	1.7 +/- 0.2	1.3 +/- 0.2	F=1.8	1, 44	0.20
Overall frequency of wrack on beach	691	568	H= 3.1	1, 54	0.08
Overall frequency of wrack in tracks or track equivalent (in no-traffic areas)	72	11	H= 10.6	1, 24	0.001

Manipulative Experiment: direct impact

Overall abundances were highest in the bags not run over, followed by low- and high-traffic treatment bags. These differences were not statistically different (ANOVA: treatment effect, F=2.7 df=2,72 *P*=0.07), however, due to an significant emergence of tethinid flies in the high-traffic bags during period three. The tenebrionid beetle *Phaleria testacea* was the most abundant in all three treatments (31% of all individuals) and was significantly lower in the bags subjected to traffic (ANOVA: treatment, F=4.8 df=2,72 *P*=0.01). Differences in bag volume and % clumps buried were also significant.





Tenebrionidae: *Phaleria testacea*

	Control	Low-traffic	High-traffic	*P*-value
Bag dimensions (cm^3)	1521 +/- 84	920 +/- 96	881 +/- 90	<0.001
% of wrack clumps fully buried on sampling day	11.1	40.7	40.7	0.02
Relative humidity (%) at the wrack/sand interface	69 +/- 2	70 +/- 3	70 +/- 2	0.94

Conclusions

1) ORVs significantly lower the overall abundances of macroinvertebrates on sandy beaches, but individual species respond differently to traffic.

2) Mobile species that utilize the entire beach are most affected by ORV traffic. Therefore, pitfall traps are more efficient than wrack/core samples at monitoring the effects of ORVs on beach macroinvertebrates, because they are better at catching these broad-ranging species.

3) ORVs lower the overall amount of wrack debris on beaches by accelerating wrack breakdown and burial. This phenomenon contributes to the overall decrease in macroinvertebrate abundances on beaches where driving is allowed.

4) The manipulative study suggests that directly running over wrack results in lower abundances of some detritivores. However, other species can increase in broken-down wrack clumps.

Acknowledgements

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